



LAYING THE TEARS HIGHWAY- A DRIVE THROUGH ENDO-DCR

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ABSTRACT:

This article is an attempt to review the technique of Dacryocystorhinostomy in the treatment of epiphora and bring to light the various modifications that have been developed in recent times to refine the procedure and optimize the outcome of surgery.

INTRODUCTION:

To dry people's eyes' – that is one of the greatest challenges of lacrimal surgery!

Although the tear drainage system appears very simple, draining the tears through the nasolacrimal system with the help of gravity is indeed an intricate process. Drainage of tears depends on the volume of tear production, eyelid position, pump mechanisms, anatomy of the lacrimal system, gravity, and nasal air convection currents.

Although clinical evaluation of gross lacrimal function is not difficult and can be done on the basis of history, determination of the cause may be extremely difficult and requires a variety of diagnostic procedures. Lacrimal drainage dysfunction can be due to an anatomic obstruction, such as nasolacrimal duct fibrosis, or physiologic dysfunction from a failure of functional mechanisms (for example lacrimal pump inadequacy caused by poor orbicularis muscle tone); therefore, the diagnosis of the cause of epiphora is important. DCR, as a surgical procedure for the treatment of epiphora, has been found to be more useful in cases of anatomical obstruction, though its usefulness cannot be completely ruled out in cases of physiological dysfunction.

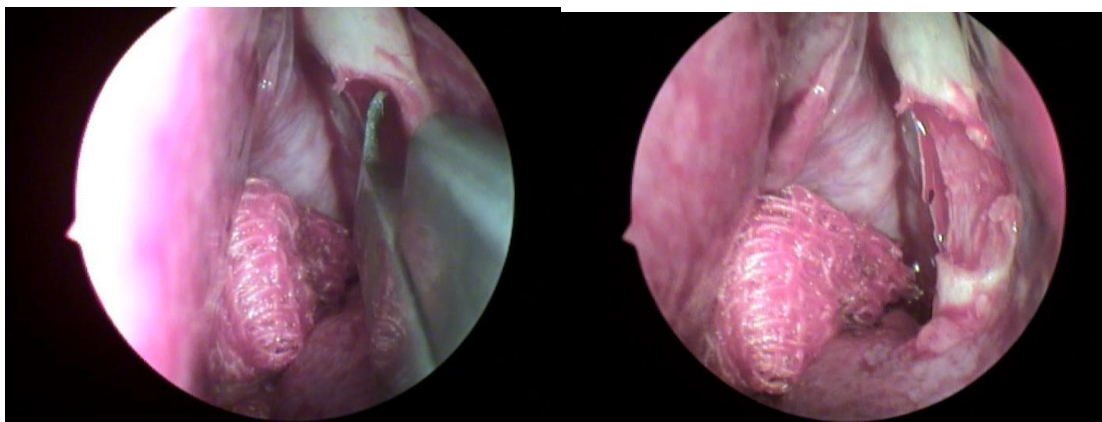
THE CLINICAL SCENARIO:

45 years old female, Mallika, hailing from Vellore, came with complaints of excessive unprovoked watering from her left eye for the last 1 year. The 1st episode was apparently following trauma. She had had 2 episodes of swelling at the medial canthal region of the left eye, which was painful, and which got relieved with an Incision and Drainage done under local anaesthesia and antibiotic cover. There were no associated visual disturbances. On lacrimal syringing, regurgitation was seen through the opposite punctum on cannulating both upper and lower puncti. There was no evidence of any facial trauma or nasal pathology/anatomic variants on CT of the facial bones and sinuses or Diagnostic Nasal Endoscopy that needed to be addressed before proceeding with lacrimal surgery. So it was decided to proceed with endoscopic Dacryocystorhinostomy to relieve the obstruction in the naso-lacrimal duct.

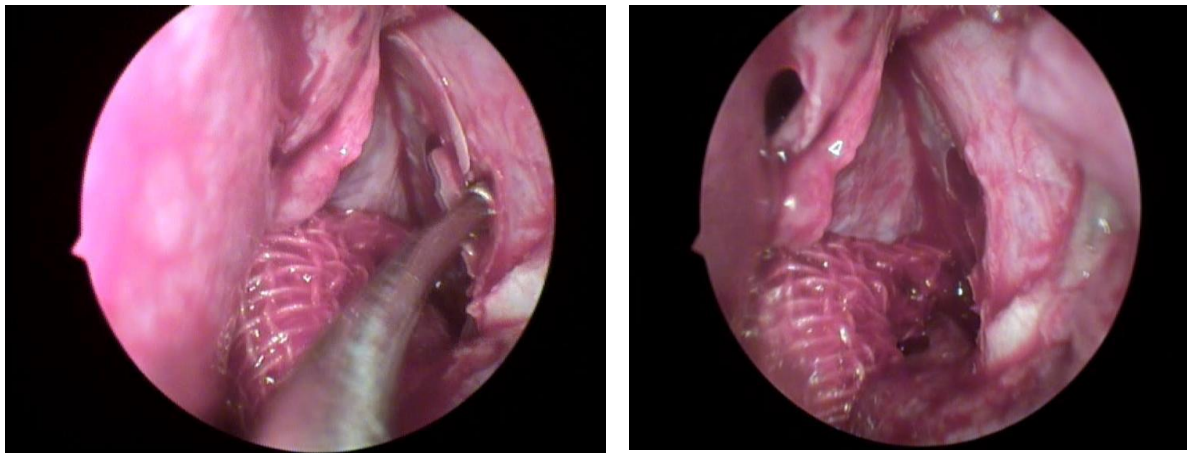
GA/LA ? :

Conditions favoring general anesthetic include acute dacryocystitis, prior surgery in the lacrimal area, and difficult nasal anatomy with a tight access, and patient preference. In both types of anesthesia, the lateral wall of the nose and middle turbinate are infiltrated with a solution of lidocaine 2% with epinephrine 1 : 100,000 and the nostril is then packed with gauze soaked in 4% lignocaine with epinephrine. This induces good vasoconstriction and decongestion of the nasal mucosa allowing optimal visualization and minimizing bleeding.

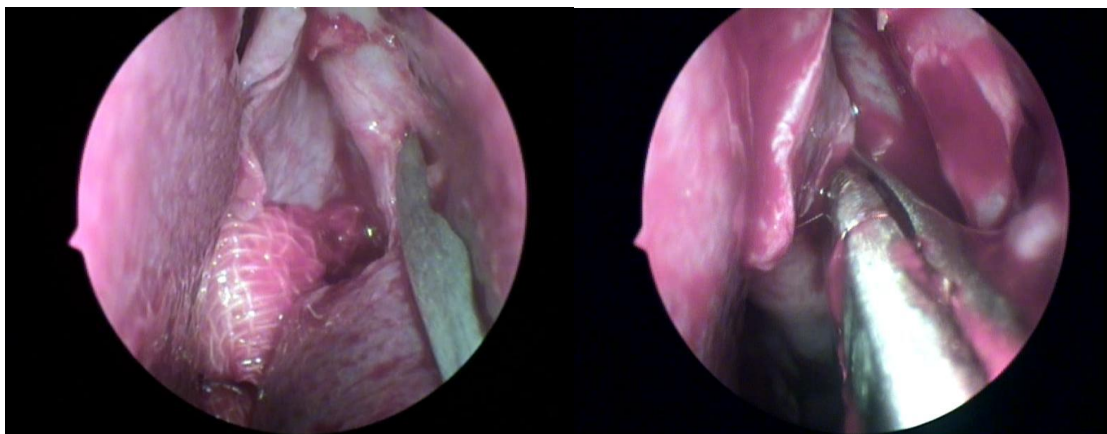
In our case, GA was preferred by both the patient and us (as she was a very anxious lady and we were doubtful if she would co-operate well enough to achieve optimal results under LA). After achieving adequate anaesthesia and de-congestion, the incision was started 8mm above insertion of the middle turbinate, brought about 8mm anteriorly and then turned down vertically unto about midway of the anterior face of the middle turbinate.



Vertical limb of the incision being made in the lateral wall of the nose:



The medially tented lacrimal sac is incised and probed, and pus is drained:



Opening in the medial wall of the lacrimal sac is widened and the flap is trimmed so as to not occlude the osteotomy site:

Advised Postoperative Care

The patient was instructed to avoid nose-blowing for 10 days. Nasal irrigation with saline is done for 1 week, 3 or 4 times daily. An antibiotic–steroid combination eyedrop is used for a week in the operated eye. The lacrimal system is irrigated daily for 1 week and at 1 month. Endoscopy can be performed at 1 week if cleaning of the nostril is believed to be necessary and at 1 month to confirm adequate healing of the surgical site. A final follow-up is done at 3 months to confirm the patency of the lacrimal passage and rehabilitation of the nasal anatomy.

DISCUSSION:

HISTORY:

History of surgery for nasolacrimal pathway obstruction dates back to Hamurabi 2200 B.C

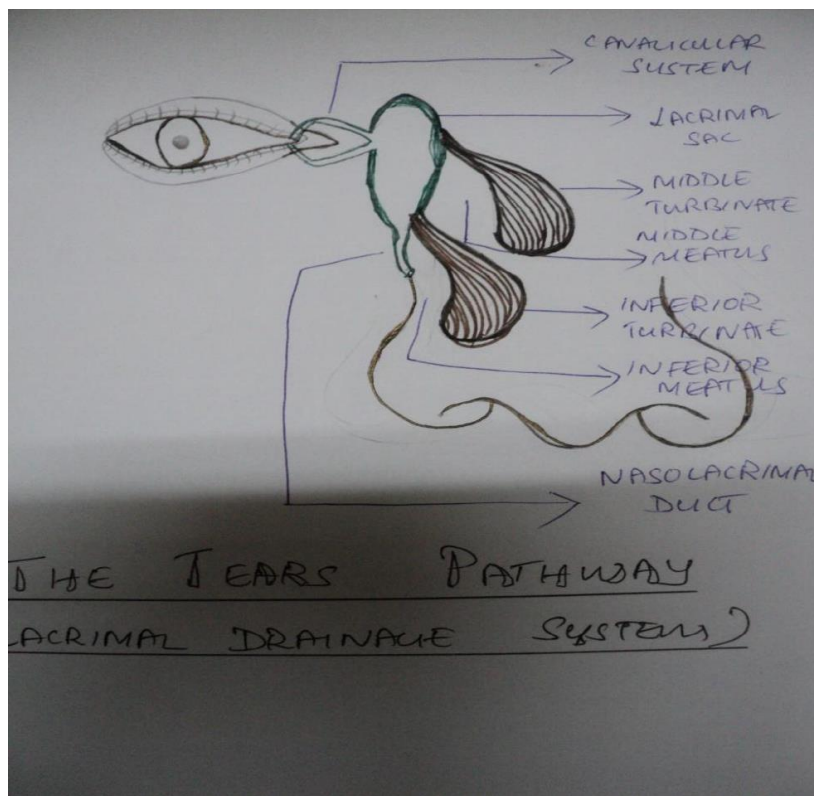
External dacryocystorhinostomy (DCR) was first described by Toti in the early 20th century.

The intranasal approach to lacrimal surgery was first described by Caldwell in 1893 however, it quickly fell out of favour because of difficulties viewing the intranasal anatomy through the nose. Attention returned to the intranasal approach after Heermann in 1958 introduced a direct technique for endonasal lacrimal surgery using an operating microscope that produced very good results. Routine utilization of endoscopes by ears, nose, and throat surgeons led to renewed interest in approaching the lacrimal duct from the nose. The first modern endonasal DCR procedures using endoscopes were described by McDonogh and Meiring in 1989. Especially in America, early endonasal DCR techniques frequently included the use of lasers to burn through the mucosa and create the osteotomy. However, the laser-assisted endonasal DCR yielded inferior results compared with the external route. This was likely the result of the generation of excess granulation tissue and char around the ostium in the postoperative period.

RELEVANT CLINICAL ANATOMY:



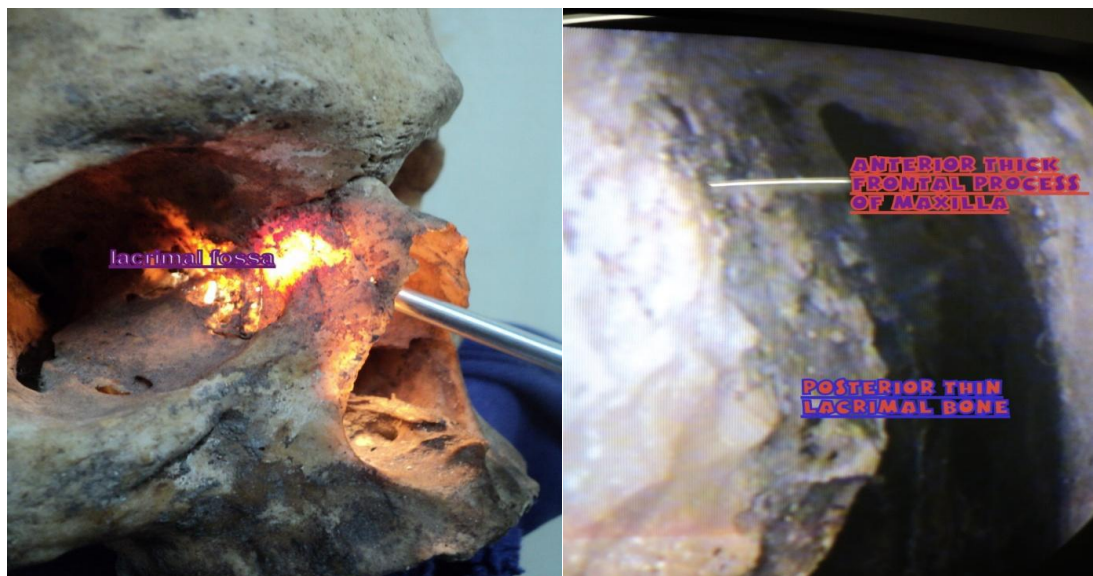
The shaded area in black represents the lacrimal fossa:



Tear fluid is drained by the nasolacrimal ducts into the inferior meatus of the nose. The main lacrimal gland and 10-12 secretory ducts are located within the supero-temporal conjunctival fornix. The accessory glands of Krause and Wolfring are located in the conjunctival fornix and palpebral conjunctiva respectively. Whitnall's ligament provides structural support and prevents prolapse of the gland. The lacrimal passages consist of a bony passage and a membranous lacrimal passage. The bony passage is formed anteriorly by the frontal process of the maxilla and posteriorly by the lacrimal bone. The membranous lacrimal passages include the lacrimal canaliculi (which starts at the lacrimal puncti), the lacrimal sac, and the nasolacrimal duct. Each punctum opens into an avascular mound of fibrous tissue – the lacrimal papilla. Each punctum, measuring about 0.3mm in diameter, leads into a canaliculus, which extends 2mm vertically and then turns 90 degrees medially towards the medial canthus, and travels through the orbicularis oculi muscle for about 8mm before opening into the lacrimal sac at an acute angle. The superior and inferior canaliculi unite to form a common canaliculus before opening into the lacrimal sac in majority of the individuals. The common canaliculus and lacrimal sac are located between the anterior and posterior limbs of the medial canthal ligament. The valve of Rosenmuller, located in the medial aspect of the lacrimal sac, prevents tear reflux. The upper and lower canaliculi are lined by pseudostratified and stratified columnar epithelium and are surrounded by a dense ring of connective tissue, as well as by muscle fibers of the lacrimal portion of the orbicularis oculi muscle (Horner's muscle), which surrounds the deep portion of the medial canthal tendon and the dome of the lacrimal sac. The lacrimal sac measures about 12-15 mm in height, extending about 5mm above the medial canthal ligament. Intranasally, the lacrimal sac lies about 8mm above the insertion of the middle turbinate. The rounded lower end of the lacrimal sac is continuous with the nasolacrimal duct which travels about 11mm within the bony nasolacrimal canal into the inferior meatus (about 5mm intranasally), emptying 15mm above the nasal floor. The valve of Hasner, is a mucosal fold which is present at the nasal opening of the naso-lacrimal

duct. The lacrimal sac and the nasolacrimal duct are lined by a double layered epithelium and are surrounded by a wide ranging vascular system comparable to a cavernous body. The double-layered epithelium is composed of a superficial columnar layer and a deep flattened layer of basal cells. Both layers sometimes appear as a pseudostratified epithelium. Kinociliae-lined single epithelial cells are a common finding in the lower part of the nasolacrimal duct; however, most epithelial cells are lined by microvilli. In addition to the epithelial cells, goblet cells are integrated in the epithelium as single cells or form characteristic intraepithelial mucous glands.

An important anatomical landmark during endoscopic – DCR is the maxillary line. This is a curvilinear eminence that projects from the anterior attachment of the middle turbinate superiorly, extending inferiorly along the lateral nasal wall to end at the root of the inferior turbinate. Extranasally, the maxillary line corresponds to the suture line between the lacrimal bone and the maxilla within the lacrimal fossa. Intranasally, the maxillary line marks the line of attachment of the uncinate process to the maxilla.



INVESTIGATIONS BEFORE DCR: OFFICE EVALUATION OF LACRIMAL DISEASE

PROPER AND ADEQUATE HISTORY-TAKING to identify whether the epiphora is due to :

1. Overproduction of tears (bilateral) or
2. An obstruction to drainage (unilateral) and whether there is any
3. Recent history of infection.

PHYSICAL EXAMINATION OF:

1. The eyelid
2. Puncti
3. Medial canthus

Slit-Lamp Examination by the Ophthalmologist.

Diagnostic tests for the lacrimal system

1. Schirmer's test
2. Dye (fluorescein) disappearance test
3. Primary Jones dye test (Jones I and Jones II)
4. Punctual dilatation and canalicular probing
5. Lacrimal irrigation
6. Lacrimal endoscopy

Radiological Evaluation of the Lacrimal System:

1. Lacrimal Ultrasonography
2. Dacryocystography
3. Macro - Dacryocystography
4. Radionuclide dacryoscintigraphy
5. Computed tomography
6. Computed tomography dacryocystography
7. Magnetic resonance imaging
8. Magnetic resonance dacryocystography

Examination of the punctum is to exclude agenesis, stenosis, ectropion, or any other abnormality. *The medial canthal area* is palpated to look for any firm mass that might represent a mucocele, dacryolith, or a tumor.

CT DCG has been found to be more useful than MR DCG for the study of the canaliculi. However, they have been found to be equally beneficial in studying the lacrimal sac and duct. If tumor is suspected or there is a history of midfacial trauma, further evaluation with computed tomography scan and/or bone subtraction dacryocystography is necessary.

Lacrimal system irrigation will confirm obstruction and allows the assessment of the common canaliculus and internal punctum because exploration of the common canaliculus cannot be performed easily during endonasal DCR.

Careful evaluation of the nasal cavity using an endoscope is crucial to assess the nasal access to the lacrimal sac. A large medial turbinate, nasal polyps, granular inflamed mucosa, tight nostrils, and septal deviations are all potential problems that can make endonasal DCR more difficult or impossible.

Dacryocystography is a safe, quick, and easy procedure using a radio-opaque material. It is widely established for the demonstration of stenosis. This procedure should not be performed in the presence of active dacryocystitis. Dacryocystography may be useful in demonstrating localized stricture, partial obstruction, lacrimal diverticuli, fistulae, dacryoliths, and extrinsic and intrinsic tumors of the lacrimal drainage system.

The disadvantage of dacryocystography is that it provides restricted functional information, as in dysfunction of the canalicular muscle pump, slight narrowing of the ductal lumen and mucous membranes, since intubation of the canaliculi and active injection of the contrast material may overcome stenosis.

Dacryoscintigraphy is also a simple, noninvasive physiologic test. Dacryoscintigraphy may provide information about physiological function. Limiting factors are the methodologically

inherent minimal morphologic information and relatively large variations of normal transit times. Dacryocystography gives finer anatomic detail; however, dacryoscintigraphy is a more physiologic assessment since no instrumentation is necessary.

DCR : INHERENT ADVANTAGES, DISADVANTAGES, INDICATIONS & CONTRA-INDICATIONS:

The disadvantages of external dacryocystorhinostomy

- Cutaneous scar
- Disturbance of the nasolacrimal pump system
- Bleeding
- Acute dacryocystitis with abscess formation

The advantages of the endonasal DCR procedure

- Less disruption of medial canthal anatomy
- Preservation of lacrimal pumping function
- No external incision, with improved cosmesis
- Decreased postoperative morbidity and enhanced recovery
- No hospital stay required
- Operating under direct vision with minimal trauma
- Addressing the nasal and paranasal sinus abnormalities through the same surgical approach
- Can be performed in patients with acute dacryocystitis with abscess formation
- Endoscopic postoperative evaluation for persistent or recurrent disease
- Decreased operative time
- Excellent visualization
- Ability to evaluate the location and size of the rhinostomy site
- Decreased intraoperative hemorrhage
- Can be used for previously radiated patients
- Can be used for pediatric patients
- Revision procedures

The disadvantages of the endonasal dacryocystorhinostomy procedure

- Suspicion of lacrimal system neoplasia
- Technical difficulty in patients who have sustained severe midfacial trauma with secondary hyperostosis, or altered anatomy involving the bones surrounding the lacrimal sac
- High equipment cost
- Steep learning curve.

DCR indications: Generally, this procedure is indicated when the level of obstruction is determined to be at or distal to the junction of the lacrimal sac and duct.

1. Primary Acquired Naso-lacrimal Duct Obstruction
2. Secondary Acquired Naso-lacrimal Duct Obstruction (secondary to specific inflammatory/infiltrative disorders)
3. Lacrimal duct injuries associated with sinus surgery
4. Selected cases with history of facial trauma
5. Some atypical forms of congenital dacryo-stenosis.
6. Chronic epiphora caused by acquired dacryostenosis.

7. Acute or chronic dacryocystitis with or without the presence of a dacryolith.
8. Children with recurrent dacryostenosis despite probing and lacrimal intubation.
9. Endonasal DCR has also produced good results in patients with functional nasolacrimal duct obstruction as determined by dacryocystography and lacrimal scintigraphy.
10. Medial mucosal common canalicular obstruction – this is the most common cause of proximal obstruction due to a thin membrane which can be treated with DCR and stenting.

DCR is contraindicated in

1. Lacrimal sac malignancies. In the presence of any suspicion of a mass in the lacrimal system, external DCR with biopsy is mandatory. The symptom of bloody tears is particularly worrisome for tumor. Other suspicious findings include the presence of a non-compressible indurated mass, possibly with fixation to the underlying bone and/or extension above the medial canthal tendon. An atypical age of onset of obstruction (young adulthood) and a bony obstruction seen on radiological studies also warrant further investigations for a possible malignancy. If intraoperative frozen sections are available, it may be possible to complete the DCR if the sections are benign. If malignancy is found, however, dacryocystectomy with appropriate margins should be performed, and creation of an ostium into the nose should be avoided.
2. An anterior diverticulum arising from the lacrimal sac may not be effectively managed via the endonasal approach.
3. Common canalicular stenosis
4. Retrieval of large lacrimal system stones
5. Patients with a history of midfacial trauma may have altered anatomy involving the bones surrounding the lacrimal sac, making endonasal DCR hazardous with less predictable outcome.
6. Sarcoidosis (poorer surgical results)
7. Active Wegener's granulomatosis.

Revision Endoscopic Dacryocystorhinostomy:

The principles of revision DCR are similar to those of primary DCR. The most important factor that determines the success of revision surgery is the size of the lacrimal sac. Preoperative DCG should be obtained for all patients who have undergone prior DCR (either external or endoscopic) to evaluate the size of the lacrimal sac. If the sac is of normal size, then the success rate of the procedure is similar to that of a primary procedure. However, if there is scarring and cicatrization of the sac, the success rate is lower, because even with full sac exposure only a small amount of lacrimal mucosa can be marsupialized. This leads to a higher risk of repeated scarring and stenosis. Analysis of outcomes shows that revision surgery has very acceptable rates of success. In cases in which there is significant scarring and stenosis of the lacrimal sac, the agger nasi mucosa has been used as a free graft to create functional mucosa surrounding the common canaliculus–sac junction.

Reasons for failure

- *Improper placement of the ostium*
- *Creating a small bony ostium*
- *Sump syndrome*
- *Insufficient membranous rhinostomy*
- *Scar formation in the area of rhinostomy*
- *Scarring at the canaliculi–sac junction*

- *Small cicatrized sacs*
- *Associated nasal or paranasal sinus abnormalities*
- *Development of adhesions between the rhinostomy site and the middle turbinate or rarely the nasal septum*
- *Granuloma formation*
- *Insufficient removal of periosteum*
- *Leaving behind bony spicules in the operating area*
- *Lacrimal pump insufficiency*
- *Persistence of a lacrimal sac diverticulum that was not drained*
- *Previous surgery, chemotherapy, or radiotherapy for paranasal sinus malignancy*

Endonasal endoscopic or microscopic DCR is generally the preference of many authors in instances of failed DCRs. The angled instruments developed for endoscopic sinus surgery allow the occluded ostium to be relatively safely evaluated under direct endoscopic visualization. The residual lacrimal sac can be easily accessed through the bony ostium created at primary surgery and the same can be enlarged.

The endonasal approach is a one-stage procedure that permits correction of associated nasal disorders, such as septal deviation, middle-turbinate hypertrophy, or polypoidal disease, which may be a causative factor in the failure of DCR.

In revision cases, functional dysfunction and canalicular obstruction should be considered in the differential diagnosis of epiphora before surgery.

Check for the possibility of an agger-nasi cell blocking drainage while performing revision DCR. The bone removal can be proceeded from anterior to posterior or posterior to anterior. Since the posteriorly placed lacrimal bone is thinner, it may seem easier to start from posteriorly. However, some surgeons prefer to start from the anteromedial thicker bone, so as to safely expose the lacrimal sac first. The Kerrison's punch forceps or back-biting forceps can be used for this purpose. The use of a laser takes more time and may cause thermal injury. The laser can only ablate the much thinner lacrimal bone. Removal of part of the frontal process of the maxilla gives better access and visualization of the lacrimal sac, but a laser cannot ablate this thick bone. The vascularized white color of the sac is characteristic and can easily be identified. The medial part of the lacrimal sac should be fully exposed. A lacrimal probe may be used to identify the lacrimal sac. The tenting of the medial sac wall by the probe is visualized endonasally. While it is tented by the lacrimal probe, the sac mucosa is incised with a sickle knife. Mucopus, residual contrast material, may drain from the sac, or dacryoliths may be seen in the interior of the sac. The intranasal opening may then be widened using through-cutting instruments. A carbon dioxide laser can also be used. As much of the medial wall of the sac should be removed as possible. An intranasal opening of about 10mm is advocated.

In revision procedures orbital soft tissues and internal common punctum may be incorporated into the scar tissue. Vigorous avulsion of this cicatrix may cause injury to orbital soft tissues, medial canthal ligament, and internal common punctum. It has been recommended to observe the medial commissure while gentle traction is placed on the tissue to be removed at the rhinostomy site. Excessive movement of the medial commissure by this manoeuvre may signify that deeper tissues than desired are being grasped by the forceps.

Silicon tube intubation is recommended in revision cases and they should be left in situ for at least 2 months.

Mitomycin C, an antiproliferative agent, was also used to inhibit fibrous tissue growth and scarring at the osteotomy site and to decrease the failure rate. Cottonoids soaked with 0.2 mg/ml mitomycin C are applied to the osteotomy site.

The following are some important points to keep in mind while performing revision-DCR surgery:

- 1. The sac should not be opened very high up without opening it inferiorly in order to prevent sump syndrome. High and small rhinostomies may cause sump syndrome.*
- 2. Preservation of as much mucosa as possible is of paramount importance to decrease scarring.*
- 3. The bony osteotomy should be as big as the mucosal opening (7–10 mm) and the periosteum should be removed with mucosa (since new bone formation requires the presence of periosteum)..*
- 4. The medial membranous sac wall should be removed. Only puncturing the medial membranous wall decreases the success rate.*

DCR IN CHILDREN:

EMBRYOLOGY: The development of the lacrimal outflow system begins with a thickened ridge of cells of the surface ectoderm at the naso-optic fissure. In the 12 week embryo, these cells dive into the surrounding mesoderm to form a solid cord of cells, elongating in a direction from the future medial canthus towards the primitive nasal cavity. The canalization of this solid cord into a hollow tube should be complete by the 6th month of gestation. The canaliculi open into the eyelid margin during the 7th month, just before the eyelids separate. A persistent membrane at the junction of the tubes is believed to represent the embryological basis of CNLDO (Congenital Naso-Lacrimal Duct Obstruction). Post-nasal suckling and respiration are believed to play an important role in the rupture of such membranes. A study has revealed that 70% of still-born infants have CNLDO at birth.

Many new-borns suffer from congenital obstruction of the lacrimal pathways. The rate of congenital membranous stenosis of the lacrimal excretory systems in new-borns has been reported to be as high as 50%. Fortunately, there is a high rate of spontaneous relief of the epiphora within the first 9 months of life; thus, repair of a lacrimal duct obstruction should rarely be done prior to this age. The majority of these congenital lacrimal duct obstructions can be managed well with nasolacrimal probing and intubation. These abnormalities include dacryocystitis,

Chronic dacryocystocele, amniocystocele, punctual agenesis, lacrimal fistulization, and common canalicular scarring. Also, epiphora due to a congenital lacrimal duct obstruction that has not improved with appropriate probing techniques might necessitate a DCR. Special instruments should be used such as a 2.7 mm endoscope and Kerrison rongeurs with 1mm bite.

Possible complications include excessive perioperative and postoperative epistaxis. The blood volume of children and especially babies is small as compared with an adult. Hence, excessive blood loss is less well tolerated. Endoscopic removal of fibrin clots and crusts necessitates general anesthesia; therefore, the indication for such a procedure should be restricted; as such cases with a “second look” do not show an improved outcome. Others include infection and granuloma formation.

MODIFICATIONS IN THE TECHNIQUE OF ENDO-DCR:

MINIMALLY INVASIVE PROCEDURES:

The desire for lacrimal surgery without scars led to the endonasal DCR technique. Over the years, diverse modifications have been developed. To minimize operative trauma, these endonasal techniques were supplemented by the use of various lasers such as Holmium, potassium titanyl phosphate (KTP), or carbon dioxide.

LASER – ASSISTED ENDO- DCR:

In an attempt to achieve precise bone removal with meticulous hemostasis, the laser DCR was developed and first described by Massaro et al. (1990). This report involved one patient on whom the argon laser was used and the success rate was 100%.

It is indicated

- when a patient is anticoagulated or has a coagulopathy.
- patients who are unfit for GA as it can be performed under LA.
- A relative indication is for revision surgery for a failed external DCR when there is often only a thin membrane blocking the rhinostomy.

Laser-assisted endoscopic DCR is only indicated in obstructions to tear drainage distal to the lacrimal sac.

It is mandatory to enquire about previous nasal trauma and surgery.

A history of recurrent nasal infections indicates nasal pathology which must be addressed before undertaking DCR.

The type of laser appropriate for a DCR would allow delivery via flexible optic fibers, achieve effective bone ablation and provide good hemostasis with a relatively shallow depth of penetration.

Hence, Suitable lasers include:

the KTP/532, Holmium:YAG, and diode laser.

The carbon dioxide (CO₂) laser is not ideal due to its poor hemostatic properties, poor bone ablation, and cumbersome delivery system.

The Argon laser also has relatively poor bone ablation.

The holmium YAG laser has multiple use specifications, but causes tissue splattering and lens soiling.

The KTP laser vapourises bone effortlessly with less tissue splattering.

The endonasal laser DCR (ELDCR) is similar to the cold-instrument endonasal DCR (EDCR) technique with the exception that laser energy is used to vaporize the mucosa and ablate the bone to create a fistula; however, the success rates following non-laser EDCR are somewhat higher with a number of studies quoting success rates of over 90%. The better surgical outcome with conventional surgery is related to a wider bony opening and it obviates the thermal damage caused by the laser which produces more fibrosis and occlusion at the rhinostomy site.

One major advantage of the laser is its ability to secure intraoperative hemostasis. Minor bleeding can be controlled with a few laser strikes in defocused mode. Any bleeding which is not easily controlled by a few laser strikes in a defocused mode should be controlled with application of topical decongestants or vasoconstrictors on pledgets.

PROCEDURE:

The upper punctum is dilated and cannulated (rather than the functionally more important inferior punctum) and the vitreo retinal light pipe inserted. The pipe is advanced, initially in a vertical direction through the punctum for a millimeter or so, and then horizontally along the canaliculus towards the medial canthus. Some resistance is then felt at the common canaliculus (the soft stop) before it touches the mucosa of the medial wall of the sac (hard stop). From the hard stop, the pipe is withdrawn if the light pipe is accurately positioned in the lacrimal sac, it is usually seen as a bright and sharp spot illumination underneath the tissues, just anterior to the attachment of the bony middle turbinate to the lateral nasal wall.

The area of maximal brightness corresponds with the posterior end of the lacrimal sac where the overlying bone is thinnest, not the center of the sac. The mucosa of the transilluminated area is infiltrated with lignocaine and adrenaline. A lacrimal or anterior agger nasi cell may lie between the lacrimal sac and lateral nasal wall and cause diffusion of this light. Such a cell needs to be opened prior to entering into the lacrimal sac.

The transilluminated area of mucosa covering the medial lacrimal bone is vaporized using the laser and then continued through the bone to make a shallow pit about 4–5 mm in diameter. The transillumination becomes brighter as the bone is thinned. The difficulty of this step depends on the thickness of the fronto-nasal process of maxilla.

Bleeding can usually be arrested by using the laser in defocused mode. The vaporization is continued until an opening of around 5–8 mm is created. The laser cannot ablate charred tissue and so with continued use on such tissue heat is dissipated through the surrounding tissues increasing thermal injury. Next the lacrimal sac mucosa is vapourised after confirming its position using the light probe. Suction will be needed to clear the laser plume.

The rhinostomy should be located as low as possible as a high rhinostomy results in a sump syndrome, predisposing to recurrent infections of the sac and the duct.

Next syringing should be done and free flow ensured.

Finally a stent may be placed to ensure rhinostomy patency until epitheliasation. The loop of the stent at the medial canthus should not be excessively tightened to avoid granuloma formation at the rhinostomy site and also prevent ‘cheese-wiring’ through the canaliculi.

Post-operatively the rhinostomy site does not require regular surgical debridement. Patients are usually remarkably well following a laser DCR performed under LA/GA. There is minimal discomfort or bruising of the eye, unlike the external approach.

Patients are instructed to douche their nose with saline. Patients are instructed to avoid heavy lifting, bending, or straining, or blowing their noses for 2 days. Slough covers the fistula within 48 h and this clears up within 10 days. The stent can be removed at a 6-week post-op visit.

Application of anti-mitotics does not seem to improve the success rate of laser DCR.

Complications of laser DCR:

- Stenosis (re-stenosis rates are 10% higher than with conventional techniques)
- Granulation tissue
- Synechia
- Stent migration
- Sump syndrome
- Cutaneous fistula (rare)
- Hemorrhage (rare)

Postoperative care is more involved with any endonasal and laser-assisted procedure than a conventional external DCR. The ostium must be examined and debrided as necessary. The low intensity helium-neon laser has been reported to diminish healing time because of its anti-inflammatory properties. The treatment was also noted to retard the propagation of granulation tissue.

The success rate of laser-assisted DCRs ranges from 0% to 100%.

Limitations of the procedure include damage to tissue surrounding the ostium from the heat generated by the laser. Additionally, the size of the ostium is limited because of the power of the laser. The expense of the equipment, training of personnel, and safety issues are also factors that must be considered in the use of the lasers.

However, the ability to perform the surgery quickly, under local anesthesia, and with potentially less bleeding is appealing.

MENDCR (Mechanical Endonasal DCR with mucosal flaps)

The key to improving the success rate of endo-DCR is not replicate the external procedure as closely as possible. Hence the main concept in MENDCR is the creation of a large bony rhinostomy and mucosal flaps. The size of the rhinostomy created should be similar to that created in external DCR. Another key factor in MENDCR is mucosal preservation. This procedure involves the preservation of nasal mucosa and the fashioning of lacrimal sac flaps to achieve mucosal apposition of the marsupialized sac and nasal mucosa.

Following decongestion and anaesthesia:

Step 1 : mucosal incision : using a # 15 scalpel blade, the superior incision is made 8mm above the insertion of the middle turbinate on the lateral nasal wall. The incision is brought 8mm anteriorly and run down vertically along the frontal process of the maxilla about 2/3rd of the anterior length of the MT. It is finally taken posteriorly to the insertion of the uncinate process.

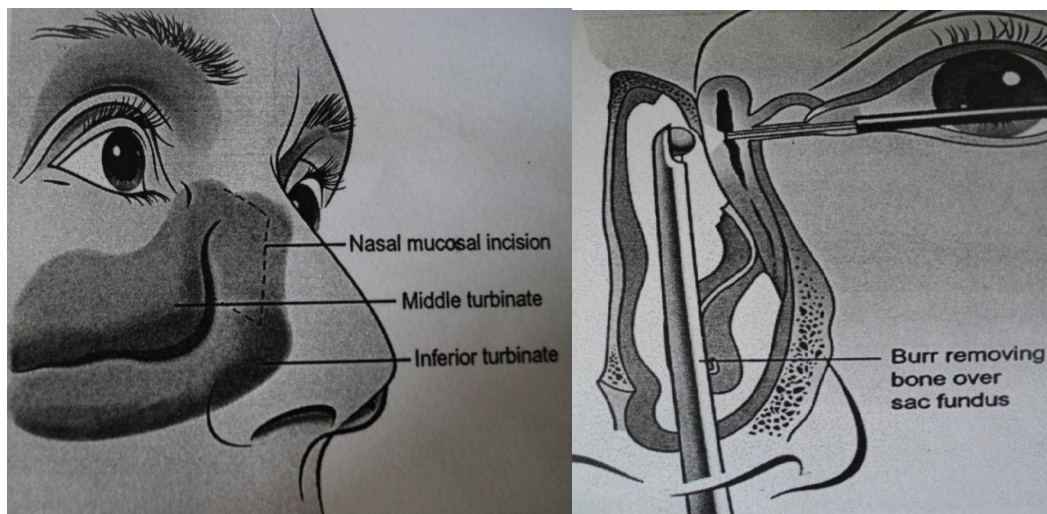
Step 2 : flap elevation: a suction Freer's elevator can be used to elevate the mucosal flap exposing the underlying bone.

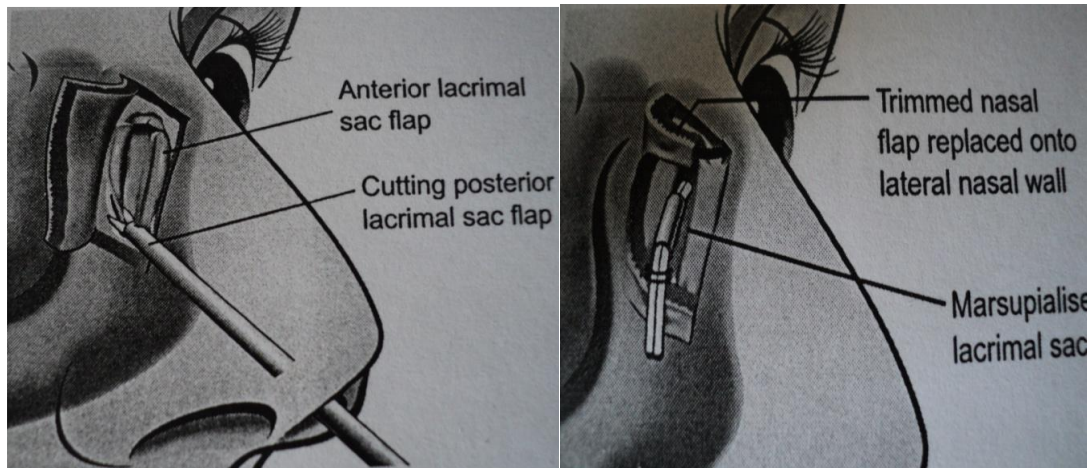
Step 3 : bone removal: the posterior soft lacrimal bone is easily removed using a Rosen's knife. Further the anterior thick bone of the frontal process of the maxilla is removed using a Kerrison's punch or micro-drill and angled DCR diamond burr to fully expose the lacrimal sac. The rhinostomy opening should measure at least 15-20mm for optimal results.

Step 4 : marsupialisation of the lacrimal sac: after indenting the medial wall of the lacrimal sac medially, the lacrimal sac is incised as posteriorly as possible vertically to create a large anteriorly based flap of the lacrimal sac. After making horizontal releasing incisions, the flap is rolled back and marsupialised. The opening should be wide enough that the common canaliculus opening in the lateral wall of the lacrimal sac is easily visualized.

Step 5 : fashioning of nasal mucosal flaps: the original nasal mucosal flap is trimmed in the middle to create a C-shaped posteriorly based flap to cover the raw bone above and below the rhinostomy opening.

Step 6 : lacrimal intubation: using O-Donoghue silicon lacrimal intubation tubes, which can be covered with steroid-soaked gelfoam to achieve optimal results.





COMPLICATIONS:

- ☐ Dissection too far posteriorly damaging maxillary and/or frontal sinus drainage.
- ☐ Entry into the orbit – orbital fat protusion/injury to extra-ocular muscles.
- ☐ Inappropriate superior dissection in children – skull base injury – CSF leak.
- ☐ Post-operative haemorrhage.

Endoscopic Radiofrequency-Assisted Dacryocystorhinostomy (ERA-DCR):

The Ellman-Javate DCR electrodes are preferred for endonasal DCR.

Radiosurgery has been shown to be superior over electrocautery because it results in less lateral thermal damage to tissues. It also produces significantly less tissue damage than KTP, YAG, or pulse CO₂ laser surgeries. An added advantage is that the electrodes are also self-sterilizing. The difference between the two high-frequency modalities is that, in electrocautery, the filament resists an electric current passing through it and becomes red-hot. This heat (not the electric current) transfers from filament to the tissues. In electrosurgery (radiosurgery), electromagnetic radiation is passed to the patient and converted to heat because of the resistance offered by the tissue cells. Whereas electrocautery operates optimally within the frequency range of 0.5–1.5 MHz, radiosurgery obtains best results within 3.8–4.0 MHz. There is less trauma to cells, less fibrous scarring, and less postoperative discomfort because a radiofrequency of 4 MHz is very gentle on the tissues with the active electrode remaining cold.

The only difference in this technique from the conventional endo-DCR and its laser modification is that, the incision over the nasal mucosa and later the lacrimal sac are made with the electrodes of the radio-frequency unit set in coagulation mode.

ERA-DCR, allows the identification and correction of any intranasal pathology that may cause DCR failure, lacrimal sac biopsy under direct visualization, and success rates approaching 98% for long-term patency of the intranasal ostium.

PRECAUTIONS: The radiosurgical instrument should never be used in the presence of flammable or explosive liquids or gases. It is contraindicated in patients with pacemakers, unless prior clearance is given by their primary physicians or cardiologists and steps are taken to ensure that the pacemaker is shielded from the high-frequency interference.

BALLOON DACRYOCYSTOPLASTY:

An angioplasty balloon catheter is passed over a protected guide wire. Inflation of the balloon dilates the stenosis. There is a significant predisposition to re-stenosis with this procedure.

TRANS-CANALICULAR DCR:

A laser fibre (600 micron optical fibre) is passed through the canaliculus, and its position is confirmed endonasally. The laser is then used to create a rhinostomy towards the nasal cavity and enlarged.

The DISADVANTAGES associated with the procedure are:

- Damage to the canaliculus if there is a leak of laser energy.
- Tendency for the fibre to be directed posteriorly in the direction of the orbit, which carries the possible risk of inadvertent entry into the orbit/ablation of the postero-medial wall of the lacrimal sac.
- The stoma created tends to be small and posterior.

DACRYO-ENDOSCOPY:

- The need to directly visualize pathologic changes in the lacrimal passages led to the development of rigid and flexible endocanalicular endoscopes. Because of the narrow lumen of the canaliculus, which is barely more than 1 mm in diameter, superfine flexible endoscopes (with a diameter of 0.3–0.7 mm) resulting as a modification of gastroduodenal endoscopes were developed for transcanalicular diagnostics. With a diameter of 0.3 mm, an image of 1500 pixels could be transmitted with fair quality, but details could not be interpreted and only a rough outline could be attained. By extending the diameter to 0.5 or 0.7 mm, 3000 or 6000 pixels could be transmitted, resulting in a much better image.

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- *Steps of dacryoendoscopy:*

- *(A) Dilating punctum (B) Irrigation (C) Endoscopy and irrigation*

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- An unobstructed view demonstrates the normal anatomic sequence of transcanalicular endoscopy, showing canaliculus, lacrimal sac, nasolacrimal duct, and nasal mucosa of the inferior turbinate.

- The canalicular mucosa appears white and is quite different from the reddish color of the mucosa of the lacrimal sac. The nasolacrimal duct can be recognized by its narrow shape and its reddish color. The nasal cavity is an intensively red structure, with a smooth surface and large width. Endoscopy permits differentiation of abnormal findings such as membranes, scars, acute or chronic mucosal inflammation, and foreign bodies. Even small blood deposits on the mucosa resulting from manipulation of the lacrimal passage are obvious. From the results of the endoscopy, an appropriate operative procedure can be selected. Injuries caused by the endoscope are comparable to other surgical interventions of the lacrimal passage, such as irrigation or intubation. It can be done under GA/LA.

PEDIATRIC ENDOSCOPY:

In children under the age of 2 years, a purely diagnostic dacryoendoscopy should only be performed in exceptional cases, because the small diameter of the lacrimal passage increases the risk of injury. Diseases of the lacrimal system in newborns and infants are mainly deformational in nature and in these cases, endoscopy does not provide any essential information. Only in cases of failure of other procedures will endoscopy with simultaneous endoscopic therapy be performed to attempt to avoid a pediatric dacryocystorhinostomy (DCR).

Canaliculo-DCR:

This procedure consists of resection of the stenosed segment of the common canaliculus with primary anastomoses over a stent along with a DCR. This has proved useful for distal canalicular obstruction with more than 8mm of patent proximal canaliculus.

Endoscopically assisted Conjunctivo-DCR:

CDCR is a dacryocystorhinostomy performed in conjunction with placement of a total lacrimal bypass tube such as a Jones, or Gladstone- Putterman, or Cooper tube.

Here basically, a fistula is created from the medial commissural conjunctiva into the nasal cavity, which is then fitted with a Jones' tube (Pyrex glass tube) to re-establish lacrimal drainage.

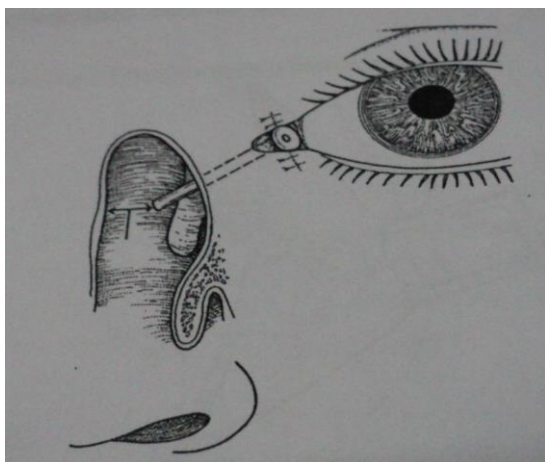
Indication are:

- Canalicular agenesis
- Canalicular (and common canalicular) obstruction
- Lacrimal pump dysfunction (facial nerve paresis)
- Herpetic infections
- Tumours
- Inflammatory conditions, Sarcoidosis, Steven-Johnson's syndrome
- Systemic chemotherapy, radiation therapy
- *Iatrogenic causes* of punctual and canalicular obstruction include chronic use of 0.125%–0.25% echothiophate (phospholine iodide), docetaxel
- permanent punctual (proximal canalicular) occlusion used to manage keratoconjunctivitis sicca.
- Trauma and idiopathic disease - the most common.
- *Infectious causes of lacrimal drainage obstruction* - trachoma, *Aspergillus*, *Actinomyces*, *Diphtheria*, and *Streptococcus* organisms.

Stagnant lacrimal sac contents can act as culture media for microorganisms such as *Staphylococcus*, *Streptococcus*, gramnegative organisms, and tuberculosis.

PROCEDURE: After anaesthesia and nasal preparation, the medial conjunctiva is exposed and the anterior half of the caruncle is excised. The soft tissues are dissected and retracted to expose the underlying anterior lacrimal crest and lacrimal bone. A high speed drill with a small cutting burr is used to remove about 8mm window of bone inferior to the caruncle, posterior to the anterior lacrimal crest. Then under endoscopic guidance, a 14-gauge intravenous catheter with an internal trocar is advanced through this window at a 45 degree angle, piercing the nasal mucosa to enter the nasal cavity anterior to the middle turbinate. The catheter is then removed and a Jones' tube (preferably of flange diameter 4mm to maximize tear drainage) is introduced through the same tract over a lacrimal probe and fixed in position nasally, endoscopically.

It has been found that endoscopically assisted conjunctivo-DCR produces superior results to external conjunctivo-DCR. This probably reflects the enhanced visualization of nasal landmarks and appropriate placement of the Jones' tube afforded endoscopically. Also, post-operative tube size and position need to be adjusted frequently, which is possible and better done under endoscopic vision.



POSSIBLE COMPLICATIONS:

- Tube migration which could in turn lead to poor tube function, naso-septal irritation and epistaxis.
- Conjunctival/corneal irritation
- Pyogenic granuloma formation which could interfere with tear drainage.

CONJUNCTIVO-RHINOSTOMY:

The conjunctivorhinostomy is indicated in patients suffering from epiphora and chronic conjunctival irritation caused by an obliteration of the upper lacrimal tract and a complete non-functional lower passage. It is also indicated when a conjunctivodacryocystorhinostomy failed in repairing a canalicular stenosis with intact lower lacrimal system or when a restenosis occurs after previous dacryocystorhinostomy in patients with saccal and postsaccal stenosis. This may be true for patients who underwent severe trauma of the eyelids and/or of the naso-orbital bony complex. Complete obliterations may occur in chronic inflammations, congenital abnormalities, irradiations, and in defects owing to the resection of malignant tumors. In many patients, the cause is idiopathic as well. This procedure is contra-indicated in patients with saccal and post-saccal stenosis.

Basic procedures in conjunctivorhinostomy:

- a** Curvilinear skin incision from the area of the medial canthal ligament along the orbital rim
- b** External rhinostomy: removal of the exposed bone below the medial canthal ligament and along the orbital rim using a diamond drill (of about 1.5cm) after cauterizing the angular vessels and elevating the periosteum of the lateral nasal wall, medial orbital wall and frontal process of maxilla. The underlying nasal mucosa should be preserved. For better exposure and access of the same, the middle turbinate may be fractured medially, endoscopically.

For the creation of the mucosal lining of the new lacrimal passage there are three options:

- a) Bipedicled nasal mucosal flap
- b) Conjunctival and nasal flap with stenting
- c) Conjunctival and cartilage containing nasal septal flap

Possible post-operative complications:

- Secondary intention healing and severe scarring. The most critical area for the development of a restenosis is the posterior wall of the new conduit next to the osseous perforation and the anterior ethmoid. Support of the lacrimal bypass by a cartilage-containing nasal septal flap provides autologous stenting of this area.
- Adhesions/ granuloma formation due to stenting.

THE USE OF MITOMYCIN C (MMC) IN DCR:

The most common cause of DCR failure is post-operative closure of the osteotomy site. This is attributed to fibrous tissue growth, scarring, and granulation tissue formation over the osteotomy site. Mitomycin C helps with this problem. MMC is an alkylating chemotherapeutic agent derived biosynthetically from 3-amino-5-hydroxybenzoic acid (AHBA), d-glucosamine, and carbamoyl phosphate. It was first isolated from the broth of *Streptomyces caespitosus* by Hata et al. in 1955. It exhibits its cytotoxic effects by the cross-linking of DNA during mitosis. It inhibits RNA replication, cell division, protein synthesis, and fibroblast proliferation. Following endoscopic DCR procedure, a cotton ball soaked with 0.1 mL of a 0.5 mg/mL solution of MMC held with a mosquito clamp is then introduced into the nostril and placed at the osteotomy site for 5 minutes. The MMC is not washed away. The use of MMC intraoperatively in external DCR or in endonasal endoscopic DCR has been shown in several scientific articles to increase the success

rate of the procedure by preventing excessive scar tissue formation at the osteotomy site. There have been no reported complications relative to its use in DCR.

5-Fluoro-Uracil (5-FU) is another antimitotic agent which is also used for this purpose.

DCR COMPLICATIONS:

Minor complications

- ☐ Ecchymosis or emphysema of the cheek, both secondary to the resection of the limits of the lateral wall. Cheek ecchymosis may also occur if the soft tissues of the cheek are exposed, when the approach was too far anterior.
- ☐ Also, dissection of the anterior aspect of the lacrimal sac may produce some bleeding intraoperatively due to the lesion of its anterior vessels.
- ☐ Burning of the skin may happen when the drill is in contact with the nostril during drilling.
- ☐ When the lacrimal sac is located more posteriorly, there might be a direct contact with the periorbit, even without the presence of a bony lamella between both; thus, when performing the incision of the lacrimal sac, the periorbit could be opened as well.
- ☐ Circumscribed exposure of the orbital fat usually has no consequences, if patients do not sneeze or blow their noses to prevent emphysema.
- ☐ Minor synechiae between the head of the middle turbinate and the lateral wall.

Major complications

- ☐ Bleeding into the orbit
- ☐ If the fixation of silicone stent in the nose has too much tension, lacerations of the inferior canaliculus may occur. Although this has no influence on the functional outcome, from the esthetic point of view it may be considered a major failure.
- ☐ Lesion of the medial rectus muscle of the orbit leading to diplopia.
- ☐ Retrobulbar hemorrhage after peribulbar injection of local anesthetics.

PREVENTION OF COMPLICATIONS:

- ☐ Cheek ecchymosis in the immediate postoperative period should be treated with ice packs. Heparin ointment
- ☐ may help in its reabsorption.
- ☐ Patients are carefully instructed not to blow their nose or to sneeze with their mouth open for a safety period of about 10 days after surgery in order to prevent increased pressure within the nose. Thus, emphysema of the soft tissues, including the orbit, is avoided. If cheek emphysema occurs, it is important to prevent its growth by prohibiting further nose blowing.
- ☐ Burning of the skin can be avoided with a long hand piece or a protected drill and using the burr only until the lacrimal sac is partially exposed.
- ☐ When bone has been left behind near the common canaliculus, it serves as a scaffold for obliterative scarring. Intraoperative removal of the bone surrounding the common canaliculus, at the superior third of the lacrimal sac, prevents the bone from acting as a scaffold for fibroblast ingrowth, and thus, obliterative scarring.
- ☐ Topical use of mitomycin C (MMC) is said to modulate the scarring process, preventing the occlusion.
- ☐ Application of artificial tears (eyedrops) containing Steroids and antibiotics help to maintain the patency.

CONCLUSION:

Despite the various modifications that have been developed, experts in the field believe that the conventional scalpel method still remains the best approach. However, it is imperative that we stay knowledgeable of the different techniques available and choose the right procedure wisely for our patients, based on its inherent advantages, disadvantages, indications and contra-indications. The attitude should be to make sure the management is tailor-made to the needs of the individual patient, and create the right bypass to the tears highway!

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